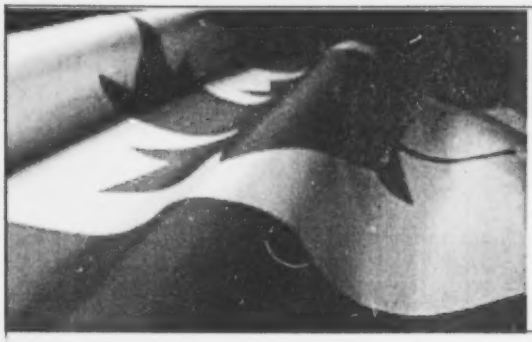

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Empirical Evidence on Human Capital Externalities

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Summary

The focus of the paper is on the extent to which human capital formation (specifically, post-secondary education and training) benefits society in general, and productivity growth in particular, over and above its benefit to the individual. The paper provides a comprehensive review of the economic literature in this area and concludes that a very rough estimate of the benefit to society of investment in post-secondary education and training is in the range of 6 to 8 percent. This is in addition to the private rate of return of about 8 percent. The existence of this societal benefit (externality) justifies government assistance to post-secondary education and training. A possible extension of this work would be to attempt to determine if current assistance levels are consistent with the estimated level of the externality.

Résumé

Ce document porte principalement sur le degré auquel la formation du capital humain (plus particulièrement l'enseignement post-secondaire et la formation) bénéficie à la société en général et accroît la productivité, en plus du simple avantage qu'en tire l'individu. Le document offre un examen exhaustif de la littérature économique publiée à ce propos et conclut que la société bénéficie des investissements dans l'enseignement post-secondaire et la formation dans une proportion approximative de 6 à 8 p. 100. Et ce, en plus du taux de rendement individuel d'environ 8 p. 100. L'existence de bénéfices sociétaux (externalité) justifie l'aide du gouvernement à l'enseignement post-secondaire et à la formation. Une suite possible à ces travaux serait d'essayer de déterminer si les niveaux d'aide actuels sont conformes au niveau estimé d'externalité.

I. Introduction

It is an odd fact that the economic basis for major elements of public policy and expenditure depends importantly on the size of one of the least well measured of all economic phenomena: human capital externalities. The case for intervention has long been thought to rest in large part on the importance of education externalities.[1] In the last 15 years the enthusiasm for measures to encourage investment in human capital has been bolstered by the rise of endogenous growth theory and empirical evidence that shows education plays an important role in economic growth (see e.g. Barro, 1991, 1997, 2001a&b). Nevertheless, the empirical basis for the belief in human capital externalities remains relatively weak.

Human capital externalities may be quite diverse. In addition to the effects on the use of technology, innovation and growth that have received most attention recently, there may be static effects on others' earnings, and non-market effects via e.g. health, fertility, longevity, crime, civic participation, political stability, level of democracy, take-up of transfer payments, and higher taxes paid by the more educated. Some of the latter effects are internal (if I practice better hygiene because I'm more educated my health, as well as that of others, may benefit), but others are external. Non-market externalities may feed back on earnings, growth etc., as emphasized in the work of McMahon (1999, 2001).

This paper attempts an overview of all kinds of human capital externalities. There is a very large literature on the topic, and it will not be possible to review every contribution carefully (to say the least!). The strategy adopted will be to summarize briefly what has been learned in the literature and look more closely at selected studies.

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[1] The other major justification for intervention is that since people cannot pledge their human capital as collateral for a loan there is a serious imperfection in the private market for student loans.

Many studies have estimated private and "total" rates of return to investment in human capital, particularly via postsecondary education[2]. In the absence of externalities, and assuming that schooling is a productive investment rather than signalling or screening, the total rate of return would coincide with the *social* rate of return.[3] However, if human capital has positive externalities then the social rate of return will be larger than the total rate of return. One of the key things to try to extract from the literature is therefore evidence on the social rate of return to human capital. As we shall see, some studies suggest that there is a significant wedge between total and social rates of return, while others dispute this.

The literature on human capital externalities is fragmented and somewhat contentious. The evidence that human capital externalities are quantitatively important has come increasingly under attack, e.g. by Heckman and Klenow (1997) and Acemoglu and Angrist (2000). This fact would hardly be evident to a reader of what might be termed the "pro-externalities" literature. (See e.g. OECD, 2001, which does not reference Heckman and Klenow, or Acemoglu and Angrist.) At the same time, the critics have not yet addressed some important contributions from the other side. This is a curious debate, but one that needs to be studied carefully.

A further point to note concerns the distinction between pecuniary and technological externalities. Perhaps surprisingly, this standard distinction is little mentioned in the empirical literature on human capital externalities. In static welfare economics pecuniary externalities are ignored unless one is interested in distribution. The reason is that for every pecuniary gain there is a pecuniary loss, and vice versa. For

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[2] See e.g. Vaillancourt and Bourdeau-Primeau (2002) for a recent Canadian study. The total rate of return, which averaged 10% for bachelors' degrees for both men and women in 1995 according to Vaillancourt and Bourdeau-Primeau, is typically less than the private return (17% for men, 20% for women according to Vaillancourt and Bourdeau-Primeau). Private returns are higher due to public subsidies for education.

[3] Under signalling or screening workers' attributes do not change during schooling. Length of schooling, or grades obtained, communicate innate skills to prospective employers. While in some models this may be productive, as a result of better worker-employer matches, in others workers' productivity on the job is unaffected. In the latter case schooling is wasteful (since it consumes students' time and other resources) and the social rate of return is less than the private rate of return. Most labor economists believe that the preponderance of evidence is in favour of a productive interpretation of schooling. See e.g. Topel (1999, p. 2972).

example, if many new lawyers are trained the fees of existing lawyers will go down, a pecuniary loss, but this is at the same time a gain to their clients. From the viewpoint of economic efficiency, "it's a wash". In dynamic analysis, however, pecuniary externalities can have real effects, as pointed out e.g. by Acemoglu (1996).[4] If more computer programmers are trained, for example, this will encourage investment in the facilities where programmers work, and also human investments by complementary workers, for example systems analysts. The result, in the end, is a net addition to national income. Perhaps because there is so much current interest in dynamics, there is little effort in the empirical literature to distinguish between pecuniary and technological externalities. The presumption seems to be that most positive externalities of education and training are "good for growth" and therefore should not be ignored in welfare analysis.

This paper is organized as follows. The evidence for market externalities is reviewed first. Section II looks at the relationship between education and growth, where most of the evidence comes from aggregate data. In Section III we look at macro evidence on static externalities, and in section IV we review static studies using microdata. Non-market externalities are considered in Section V.

II. Macro Evidence on Dynamic Externalities

Alternative macro models of human capital externalities can be discussed in the framework of the following version of the one-sector aggregate production function:

$$(1) \qquad Y = A K^{\alpha} H^{\beta} (h^{\varepsilon} L)^{\gamma}$$

Here Y is aggregate output, A is a parameter reflecting the level of technology, K is physical capital, H is the human capital stock, L is the size of the labor force, and $h = H/L$. While in neoclassical growth models A is taken as exogenous, in the endogenous

[4] Acemoglu considers alternative theoretical models showing how more human capital accumulation can

growth models of the last 15 years it often depends on H or H/L. This may reflect an effect of human capital on *technology adoption* (as in the case of an LDC that is "catching up") or on *innovation* (as in a technological leader like Europe or the U.S.). While some such effects may be internal to firms, others may represent externalities. Including H as a separate element in the production function allows the human capital stock to have positive external effects in production.

With particular parameter values, (1) simplifies to give polar cases that have been important in the literature. For example, if $\varepsilon = 0$ we get the case considered by Mankiw, Romer and Weil (1992):

$$(1') \qquad Y = A K^{\alpha} H^{\beta} L^{\gamma}$$

in which H and L enter as separate factors of production (contrary to the usual view of human capital in the labor literature). At the other extreme, $\varepsilon = 1$, and we get:

$$(1'') \qquad Y = A K^{\alpha} H^{\beta + \gamma}$$

in which the labor force enters production in effective units, $hL = H$, which is in keeping with the original spirit of human capital theory. Of special significance in either (1') or (1''), of course, is the constant returns to scale Cobb-Douglas case, in which $\alpha + \beta + \gamma = 1$.

There is now a large literature that estimates production functions like (1), (1'), (1'') or models based on such functions. The results may throw some light on how important human capital is in explaining the level or growth rate of GDP. But what can they tell us about the importance of human capital externalities? First, if estimated production functions showed increasing returns to scale that would likely be taken as evidence of human capital externalities in production. (In that case, an individual firm's production function could still exhibit constant returns, as normally expected in a competitive economy.) Second, human capital externalities may be inferred if A is found to depend on H. In that case, human capital contributes to *total factor productivity*

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reduce search costs in labor markets, and thereby encourage complementary investments.

growth (TFP). To the extent that human capital exerts its influence on growth via TFP, in the language of Romer (1993) it operates through an influence on "ideas" rather than "objects".

Neoclassical Approach

Until fairly recently, mainstream economists' knowledge of growth consisted largely of neoclassical growth theory (Solow-Swan models and the large literature that elaborated on them) and growth accounting exercises. Neoclassical growth models took growth of the labor force, labor quality, and technology as exogenous, and usually constant. The sum of these growth rates gave the steady-state growth rate of GDP. The latter did not depend on rates of saving and investment, whose impact was felt rather on the steady-state *level* of GDP.

Neoclassical growth theory seemed sensible in the light of the results of growth accounting, pursued most notably by Denison (1961). Denison found that over the period 1909-57 trend growth in output in the U.S. had been fairly steady at about 2.9%. Employed man-hours had risen at 1.3% and the capital stock at 2.4%. Lucas (1988) calculates that all but about 1 percentage point of the growth in output could be accounted for by increases in capital and labor. This residual represented the exogenous technical progress of neoclassical theory.

Endogenous Growth Theory and the Neoclassical Response

The disappointing growth experience of the 1970's and 1980's in the U.S. and elsewhere suggested that technical progress might in fact not be exogenous, giving impetus to the development of endogenous growth theory. Human capital plays a very important role in this new literature.[5] It may act as an engine of growth as a result either of externalities in human capital formation, in innovation, or in production. Externalities

[5] While human capital has the lead in much endogenous growth literature, there are models where it plays a supporting role instead. These include models where R&D investment is the key to innovation or where growth occurs by "creative destruction". (See e.g. Nelson and Phelps, 1966, and Aghion and Howitt, 1998.)

in any of these forms may clearly affect the *level* of national income, and short-run growth. If the externalities are sufficiently strong they may also affect the long-run growth rate.

The pioneer in endogenous growth theory was Romer (1986, 1990). The new theory was, however, perhaps most forcefully urged by Lucas (1988). Lucas argued that in order to understand international patterns in the level and growth rate of per capita GDP it was necessary to appeal to human capital externalities. Otherwise it would be impossible to explain the incredible diversity in GDP per capita across countries - - from lows of around $250 US in countries like India to an average of about $10,000 in advanced industrial countries. In Lucas's opinion conventional theory also could not explain the great diversity of growth rates, or the fact that flows of factors or goods did not equalize capital-labor ratios and factor returns across countries.

As is often the case, a clear statement of a new explanation for a set of empirical phenomena soon led to challenges, most notably from Mankiw, Romer and Weil (1992) - - "MRW". As is well-known, MRW tried to show that a neoclassical model could explain most of the observed differences between countries, without appealing to differences in the technology used across countries. They concluded that almost 80% of the per capita income differences could be explained merely by differences in human and physical capital and the rate of population growth.[6]

MRW have been criticized on a variety of grounds. Most significantly for our purposes, concern has been focussed on their measure of human capital investment, which was the fraction of the working age population enrolled in secondary school. Klenow and Rodriguez-Clare (1997) add primary and tertiary enrolment, and find that this reduces the fraction of income differences that can be explained using the MRW analysis from about 80% to 40%. This leaves 60% to be explained by differences between countries in "efficiency".

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[6] Since data on human and physical capital stocks were not available, MRW used investment rates instead - - which can stand in for the stocks under the assumption that countries in their steady states.

Barro (2001b) suggests a synthesis that would acknowledge that both Lucas and MRW had a point. Barro's empirical work refined the MRW approach, to produce an extended neoclassical model. But he feels that endogenous growth theory is also valuable, and sums up the contributions of the two perspectives as follows:

> "The recent endogenous growth models are useful for understanding why advanced economies – and the world as a whole – can continue to grow in the long run despite the workings of diminishing returns in the accumulation of physical and human capital. In contrast, the extended neoclassical framework does well as a vehicle for understanding relative growth rates across countries, for example, for assessing why South Korea grew much faster than the U.S. or Zaire over the last 30 years. Thus, overall, the new and old theories are more complementary than they are competing."

Barro and various co-authors have been engaged in a steady program of empirical research on international differences in income levels and growth for about the last dozen years. The landmark contributions are Barro (1991), Barro and Sala-i-Martin (1995), and Barro (1997). The latest results are summarized in Barro (2001a, 2001b), on which the following discussion is based. The approach attempts to avoid simultaneity problems by using initial levels, e.g. of GDP per capita or schooling, to explain subsequent growth.[7] The empirical strategy has been strengthened in the most recent contributions by the use of a panel structure. This allows the use of lagged variables as instruments, which again helps to deal with simultaneity problems. (See Temple, 1999.)

Barro indicates that the basis for his empirical framework can be summarized in the equation:

(2) $Dy = F(y, y^*)$

where Dy is the growth rate of per capita national income, y, and y^* is the steady-state or long-run level of y. However, more insight is provided, I think, if we also take explicit account of the fact that steady-state growth rates, g, can vary between countries. In the

neoclassical model g equals the rate of growth of effective labor units per capita, which in the original Solow-Swan models was just the rate of technical progress, g_t. These days, growth in human capital per worker, g_h, must also be taken into account. Thus $g = g_t + g_h$ and we think of both components of this steady-state growth rate as endogenous. Note further that g_t is often now believed to depend on the total or per capita stock of human capital (or perhaps the ratio of human to physical capital). Taking all this into account, Barro's (2) can be extended to:

(2') $Dy = F(y, y^*, g)$

Since y in an economy below its steady-state will rise toward y^*, when $y < y^*$ the growth rate exceeds the steady-state rate. Similarly, where $y > y^*$ the growth rate should be lower than in steady-state. This represents *conditional convergence*. The finding of conditional convergence in international comparisons, as well as for regions within countries (e.g. Japan and the U.S.) is a robust finding of Barro's work. A stylized result is that on average about 2 % of the difference between y and y^* is eroded annually.

Holding y constant, a country with higher y^* will grow more rapidly (because it is further below the steady-state). Higher y^* will come with a higher saving rate, better political institutions, lower fertility, and a less distorted economy.

Barro's central case results are shown in Table 1 of Barro (2001a) and the first column of Table 1 in Barro (2001b). They are for a panel of roughly 100 countries. Three decade-long periods are used: 1965-75, 1975-85 and 1985-95. The dependent variable is the average growth rate of real per capita GDP in each of the three periods. I summarize Barro's apparent interpretation of his results briefly for the non-education variables and then discuss the education results in more detail.

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[7] A regression of Y on current values of K, H, and L, that is an attempt to estimate e.g. (1') directly, would tend to produce biased and inconsistent coefficients since the right-hand side variables are all arguably endogenous and determined simultaneously with Y.

log y: hump-shaped effect; most of the observations are past the hump, implying conditional convergence.

Gov't. consumption: negative effect, perhaps because higher expenditures imply higher (distortionary) taxes.

Rule-of-law index: positive effect; y^* higher with more secure property rights, less crime etc.

Openness ratio: positive effect; due to higher y^*; confirms studies by e.g. Sachs and Warner (1995) that more open economies grow faster.

Inflation rate: marginally significant negative effect, interpretation unclear.

log fertility: negative effect; y^* lower.

Investment/GDP: marginally significant positive; due to higher y^*. (Barro argues that the use of lagged investment as an instrument provides "some reason to believe" the effect does not reflect reverse causation.)

Growth Rate of Terms of Trade: positive effect, interpretation unclear.

Education: The education variable is one that Barro has found over the years has the most explanatory power in this type of equation. It is the average years of secondary and tertiary schooling attainment for males aged 25 and above at the beginning of the period. There is a strong and significant positive effect. One way of gauging the strength of the effect is that a one year increase in male schooling attainment would lead, after full adjustment, to a 19% increase in GDP per capita. On the other hand, Barro (2001b, p. 30) calculates that the coefficient implies an average social rate of return to schooling of just 7%. As discussed in Bils and Klenow (2000), Psacharopoulos (1994) assembled a collection of micro-based estimates of the *private* rate of return to schooling in 56 countries that has an average rate of return of 9.9%. At first blush, this comparison would seem to suggest that the Barro results show no evidence of externalities. In the presence of externalities the social rate of return should exceed the private rate of return. However, as we shall see below, it is possible to argue that Barro's rate of return captures only dynamic returns to schooling, and that these should be regarded as *additional to* the usual micro-based rates of return.

Other results Barro reports include separate regressions for OECD, rich, and poor countries, results for primary education, and results for females. In the OECD and rich countries very small effects of education are found. These small effects may possibly be explained by small variation in schooling attainment across these countries combined with measurement error. Primary school attainment has an insignificant effect for both males and females, and female's schooling has insignificant effects on growth. The latter result may indicate that many countries are poor at harnessing females' human capital for technology adoption and other growth-promoting forces. Alternatively, some have argued that measurement problems are more severe for female schooling.

In addition to looking at the quantity of schooling, in company with a number of other recent researchers (e.g. Hanushek and Kimko, 2000; Bils and Klenow, 2001), Barro looks at the impact of schooling *quality* - - as indicated by test scores. For a subsample of about 40 (mostly rich) countries he has data on science, mathematics, and reading test scores. These turn out to be much more important than schooling attainment in explaining growth. For example, when science scores alone are added to the regression shown here in Table 1 it is found that a one-standard deviation increase in those scores would raise the growth rate on impact by 1.0% - - vs. a 0.2% increase for a one-standard-deviation rise in male schooling attainment.[8] These results seem consistent with stories that emphasize the role of schooling in speeding technology adoption or innovation - - in part via externalities.

Note that while Barro estimates the social rate of return to increasing human capital accumulation at the extensive margin - - via a one-year increase in schooling for all workers - - a parallel calculation is not made for raising investment on the intensive margin, that is in the quality dimension. The difficulty is that this calculation requires an estimate of the cost of raising average test scores, or some other measure of quality, by a given amount. (For test scores, Barro's results indicate the *benefit*, in terms of increased

[8] When included separately in the regression, science and mathematics scores both have a significant positive effect, but science scores have a larger impact. When included on their own, reading scores are insignificant negative. When math or science scores are included along with reading scores, the coefficient for the latter becomes positive.

GDP.) It would not be impossible to make such calculations. Test scores have been improving in recent years in most Canadian provinces, for example, apparently due to a more rigorous curriculum and higher standards for student achievement. Estimating how much it has cost to make these improvements should be possible. However, I am not aware of any such estimates having been made to date.

Finally, we should note that Barro's use of initial schooling attainment, a proxy for the human capital stock, rather than the growth of human capital, as a determinant of per capita GDP growth is significant. If one thinks in terms of estimating the production function (1), (1') or (1") DY is explained by DH, not by H. So, why does Barro use schooling attainment as his human capital variable? The answer can be conveniently discussed in the context of the work by Benhabib and Spiegel (1994).

Benhabib and Spiegel

Benhabib and Spiegel (1994) start by estimating (1'), in first difference form. They use cross-country data on a sample of 78 countries, and use a measure of the human capital stock derived by Kyriacou (1991). Their estimate of $\exists$ is small positive (.063) and insignificant. When initial GDP is added as a regressor, to control for neoclassical convergence, the coefficient on DH becomes insignificantly negative and remains so in several different specifications. Similar results have apparently been obtained whenever aggregate production functions are estimated in first difference form, as Pritchett (1999) and Krueger and Lindahl (2000) argue they should. (See also Bloom et al., 2001.)

While these results are surprising, they should perhaps not be entirely unexpected. While it is true that schooling levels have a strong positive crude correlation with GDP per capita growth across countries, the same is not true for *changes* in schooling. The advanced countries in the sample, which have relatively high growth rates, already had a high level of schooling attainment at the beginning of the sample period. There was little room for them to increase human capital per worker. On the other hand, many of the slowest growers started the sample period with very low schooling attainment and saw

large increases. While these observations do not *explain* why measured human capital growth has no contemporaneous impact on GDP growth, they do provide some reassurance that the regression results are believable!

Benhabib and Spiegel go on to develop a model of the role of human capital in technological adoption and innovation. Here they argue that it is the average stock of human capital in a period, rather than its growth rate, which is the critical factor. Their results bear this out, showing that the rate at which low income countries close the income gap with the technological leader in the sample is increasing in their human capital stock. For high income countries, growth is directly increasing in the human capital stock (i.e. not interacted with the income gap), which Benhabib and Speigel interpret as a sign of an innovation effect.

The Benhabib and Spiegel results suggest that the reason Barro's male schooling attainment variable has a significant positive effect on growth is not that initial schooling is a proxy for subsequent human capital growth, but that it has an impact on technology adoption and innovation. In other words, human capital has its (measured) impact on growth primarily via ideas rather than objects. Barro appears to agree with this interpretation.[9] This is why it was suggested above that Barro's estimated 7% rate of return to schooling represents only a dynamic effect - - over and above any of the usual micro-based static returns to schooling.

Bils and Klenow

The results of Benhabib and Spiegel have received strong support in a recent study by Bils and Klenow (2000). Bils and Klenow use Mincer earnings equations to impute stocks of human capital in a study that is otherwise similar to Barro's earlier

[9] This leaves one wondering why human capital does not have the expected direct impact as a factor of production. More factors are supposed to produce more output. A possible explanation is that most of the micro-based returns to schooling represent signalling or screening, rather than socially productive investment. Another possibility is that estimates of the change in human capital stocks are simply too badly measured to show up as significant. (It is well known that the impact of measurement error is increased when first differences are taken.)

work.[10] Following Barro (1991), they regress per capita GDP growth over 1960-1990 on schooling enrolment rates in 1960. They show, first, that a one-year increase in schooling leads to a rise in the per capita growth rate of GDP of 0.300 percentage points. They argue that most of this effect is due to (i) correlation of schooling with subsequent growth in the number of workers per capita in a country, (ii) reverse causation from growth to schooling, and (iii) omitted variables affecting both schooling and growth. The effect of job growth is removed by looking at GDP growth per worker rather than per capita, which reduces the impact of schooling to 0.213 percentage points. Human capital stocks are then imputed for each country, and it is found that there is a very weak relation between initial schooling and human capital growth. In fact, in some of the parameterizations considered this relationship is negative. The similarity to the results of Benhabib and Spiegel (1994) is striking.

Bils and Klenow go on to show that their direct measures of human capital growth explain a large part of the residual GDP per capita growth that cannot be explained by increases in the stock of physical capital, that is TFP growth. This is consistent with the results of Benhabib and Spiegel (1994), and again suggests that human capital externalities may be important for growth.

Heckman and Klenow

Heckman and Klenow (1997) - - "HK" - - provide a skeptical review of selected portions of the literature on human capital externalities. Some of their points relate to dynamic issues, and others to statics. The latter are discussed in the next section. They stress the following points re growth:

1. If schooling and human capital are important in explaining growth, this does not necessarily mean that human capital *externalities* are important. Human capital may be contributing simply as a private input.

2. Compared with studies of international income differences, "studies of 'dynamic externalities' to human-capital-intensive R&D are more numerous and the evidence from

[10] Mincer equations are explained in the next section.

these studies is more robust..." Readers are referred to Griliches (2001) for a survey. Many studies have found that "controlling for its own R&D, a firm experiences faster productivity growth the greater the R&D of 'technologically close' firms. And when productivity growth is regressed on R&D, the coefficient tends to be larger the higher the level of aggregation..." However HK are unconvinced by even this evidence, commenting that firms may just be responding to common shocks to the productivity of R&D or the business cycle. "Ideally, instruments could be used to deal with simultaneity, but as in many literatures the search for valid instruments has been in vain."
3. HK review the results of growth accounting exercises: Jorgenson (1995) for the U.S. and other OECD countries in the postwar period up to the mid 1980's; Young (1995) for the Asian tigers; and Klenow and Rodriguez-Clare (1997) for 98 countries over 1960-85. The broad conclusion is that there is room for externalities equal to about 50% of the "object" contribution of human capital, over and above the latter. That is, TFP growth equals about half the direct contribution of human capital. However HK are skeptical that human capital externalities can explain much of the TFP residual. They refer to Greenwood et al. (1997) who estimate that improvements in the quality of equipment explain about 60% of the TFP residual in the postwar U.S.

Hendricks

Hendricks (forthcoming) criticizes the original MRW neoclassical story from a new perspective. He starts from the observation that immigrants typically experience large earnings gains on moving to the U.S. He uses country-specific Mincer equations (see next section) to model their earnings in source countries, and compares these with their actual earnings in the U.S. Immigrants' earnings rise up to 30 times on moving to the U.S. However, Hendricks calculates, if the only differences between source countries and the U.S. were "object" differences (principally higher physical capital per person) their earnings should no more than double when they migrate. Thus, he concludes, differences in technology across countries must be very large. In other words, idea gaps must be much more important than object gaps. This conclusion once again leaves room

for human capital to affect incomes via technology - - that is through the adoption and innovation effects.

McMahon

Walter McMahon has pursued a long research program on the effects of education - - on productivity, R&D, development, and non-market variables. (See e.g., McMahon, 1992, 1999, 2001.) In McMahon (1999) he provides an ambitious study of the full benefits of education - - market and non-market, direct and indirect, internal and external, using a sample of 78 countries. He estimates equations for GDP per capita growth, and for physical investment rates, separately for each of four regions - - Africa, East Asia, Latin America, and the OECD. Data are for five-year periods from 1965 to 1990. Specifications in the four regions differ, but the growth equations estimated are broadly similar to those estimated by Barro. One significant difference is that, rather than using initial schooling attainment as his education variable, McMahon uses enrolment or education investment rates in the period 1960-65.

In addition to estimating his growth and investment equations, McMahon estimates equations using the full sample (or subsamples that have the required data) to explain, and study the effect of education on, a wide range of other variables. These include population growth, fertility, income inequality, human rights, voting rights ("democratization"), political stability, rural poverty, infant mortality, life expectancy, deforestation, and crime. He then performs simulations to explore the full effect of (i) raising male and female secondary education enrolment rates by 20 percentage points, and (ii) a 2 percentage point increase in public investment in education as a fraction of GNP. The simulations run for a period of 40 years (from 1995 to 2035), and take into account all feedbacks from market and non-market variables onto growth.[11]

McMahon's study is of special interest here, not only because of its consideration of feedbacks from non-market effects of education on growth, but because McMahon is

[11] McMahon (2001) reports further simulations that use a 45 year period.

interested in how social and private rates of return to education compare. Arias and McMahon (1998) estimated full (static plus purely dynamic) private rates of return to education in the U.S. They obtained rates of 11.3 % and 13.3 % for high school and college respectively. Taking into account all feedbacks, McMahon (1999) obtains a full social rate of return of 14 %. For the U.K., private rates of return were estimated at 13% and 11% for high school and college, while the social rate of return was 15 %. (See McMahon, 1999, p. 251.) Broadly speaking, these results suggest purely dynamic market externalities around 1 - 2 percentage points of the social return to education.[12]

OECD Countries

While Barro and others have found an impact of schooling attainment, or the human capital stock, on growth in large samples of countries, when attention is focused only on rich countries, or the OECD countries, the estimated effect is much smaller, and sometimes insignificant. (See e.g. Barro, 2001a and 2001b, or Pritchett, 1999.) The OECD, in company with e.g. Krueger and Lindahl (1999) and Temple (1999), believes that a large part of the problem may be due to measurement error in schooling attainment. De la Fuente and Domenech (2000), for example, have constructed "an improved data set using available national and international sources, with an eye to ensuring coherence over time as well as agreement with recently collected OECD data on educational attainment. Using this data set, they find that human capital does have a substantial and positive impact on growth in GDP or income per capita" (OECD, 2001, p. 31). It is also reported that OECD studies indicate "the improvement in human capital has been one of the key factors behind the growth process of the past decades in all OECD countries, but especially so in Germany (mainly in the 1980's), Italy, Greece, the Netherlands (mainly in the 1980's) and Spain where the increase in human capital accounted for more than

[12] One may ask whether these comparatively small returns are consistent with Barro's estimated 7 percent return to schooling. We suggested earlier that Barro's return may best be thought of as the purely dynamic component of the full return. McMahon finds that full private rates of return are about 3 percentage points above static private returns. Thus, Barro's 7 percent may be compared with McMahon's 1 – 2 percent *plus 3 percent*. Thus, estimates of purely dynamic returns from the two studies appear to be in the same ballpark.

half a percentage point acceleration in growth with respect to the previous decade". For OECD countries as a whole, we are told, "the implication is that each extra year of full-time education ... is associated with an increase in output per capita of about 6 percent".

OECD (2001) refers approvingly to the "generally favourable picture of the impact of human capital" provided by the review of Temple (2001). The latter concludes that "The balance of recent evidence points to productivity effects of education which are at least as large as those identified by labour economists". The OECD is effectively claiming two things. In claiming that education causes growth in the OECD countries they are asserting that the dynamic returns found by Barro, McMahon and others for large sample of countries apply also in the OECD. And by claiming that each year of education increases GDP per capita by 6 % they are asserting that previous results showing a lack of impact of human capital growth on income growth. The latter results could conceivably be reconciled with e.g. Benhabib and Spiegel (1994) or Bils and Klenow (2000) if those previous studies were severely affected by measurement error. Detailed investigation of the reasons for the contrasting results would be worthwhile.

Note, finally, that both Gemmell (1995) and Barro and Sala-i-Martin (1995) find tertiary education is relatively more important for explaining growth in OECD countries, and primary & secondary schooling more important in poor countries. To the extent that tertiary education has a special role in preparing workers for technological adoption or innovation, this seems consistent with growth effects of education in the rich countries operating largely via "ideas" rather than "objects".

Summary

While there has been heat as well as light in the literature reviewed, a somewhat consistent story seems to emerge. While there is some recent contrary evidence for the OECD, growth of human capital does not cause GDP per capita growth according to most cross-country studies. On the other hand, a large number of studies agree that the *stock* of human capital has a positive impact on growth. There is evidence that this

impact occurs via technology adoption and innovation - - with adoption most important in poor countries and innovation most important in rich countries. Human capital thus may have its growth effects primarily via reduction of "ideas gaps" rather than "object gaps". In growth accounting terms, the critical contribution of human capital may be to increase TFP growth. McMahon's estimates suggest that dynamic human capital externalities form about 1 - 2 percentage points of the social rate of return to education.

III. Static Market Externalities: Macro Evidence

Recently a number of authors have argued that it ought to be possible to apply standard labor economics techniques to cross-country macro data in order to estimate the external effects of schooling. This involves the estimation of Mincer equations using cross-country aggregate data.

The classic Mincer earnings equation was derived from simple human capital theory. (See Mincer, 1974.) It predicts the following equilibrium relationship between years of schooling, s, and earnings, E, taking into account the influence of years of experience, x:[13]

(3) $\log E = b + cs + d(x)$

where $d(x)$ is some function, often taken to be quadratic in empirical work. The coefficient c is generally interpreted as an estimate of the rate of return to schooling. Typical values in recent studies for Canada and the U.S. are in the range 0.07 - - 0.10,

[13] Mincer set out (2) as an equilibrium relationship that would have to hold in order to ensure that workers acquiring any observed level of schooling were rewarded by a rate of return on their investment, at the margin, equal to their (possibly shadow) cost of borrowing. However, the Mincer equation is almost universally interpreted these days as akin to a production function. For an undeservedly neglected discussion of the limitations of this approach see MacDonald (1981).

indicating an average 7 - 10% real rate of return (before-tax) on human capital investment.[14]

If there are static externalities to human capital, these will not show up in micro-based estimates of (3). However, in principle, such externalities should be evident in cross-country estimates of c using aggregate data. That is because the human capital market externalities will be included in a country's GDP. Thus comparisons of macro- and micro-based estimates of c ought to provide a measure of static market externalities.

Several papers have now applied the Mincer equation using macro data. Heckman and Klenow (1997) - - HK - - find a rate of return of 23.0% in their cross-country Mincer regressions. However, they find that this rate of return drops dramatically, to just 10.6%, when they introduce a life expectancy variable - - which they regard as a proxy for technology. Topel (1999) performs a similar exercise, but controls for age and year effects as well as life expectancy. He finds a drop in the estimated rate of return from 22.6% to 6.2%. Bloom et al. (2001) follow a different estimation approach from HK and Topel. They estimate a production function of the basic form (1) in first differences, but specify h as being determined by a Mincer equation. Their point estimates of the social rate of return to schooling, when life expectancy and a technological catchup variable are included, is 11.6%.[15] They conclude that their estimates "are consistent with micro estimates of the effects of individual schooling on earnings based on the Mincer earnings function, and suggest that there are no externalities to education."

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[14] Two standard concerns about estimates of c in (3) are ability bias and measurement error. Because more able people on average get more schooling, part of the effect of schooling merely reflects ability. This biases the coefficient up. On the other hand, measurement error in s biases the coefficient down. Conventional wisdom has been that the two effects are approximately offsetting. However, using a sample of identical twins to control better for ability, Ashenfelter and Krueger (1994) find that ability bias is smaller than measurement error. Their estimates of the private rate of return to schooling are in the 12 – 16% range, rather than the usual 7 – 10% range.

[15] See Bloom et al. (2001) Table 1, column 3. The coefficient on schooling (.082) must be divided by that on labor (.708) to get the estimated social rate of return. The Table 1 results constrain TFP to be constant across countries. Bloom et al. also present results (Table 2) allowing TFP to vary across countries, and introducing geographical and institutional variables. The impact of schooling becomes negative in this case.

The HK, Topel, and Bloom et al. results appear to leave zero room for static human capital externalities. However, it should be noted that all three studies make use of life expectancy as an explanatory variable. The interpretation of this variable varies between the studies. HK and Topel regard it as a proxy for technology. Bloom et al., on the other hand, regard it as a measure of health, which they believe is an important component of human capital along with schooling. Given that the life expectancy variable has such important effects on the results more investigation is needed of exactly how it exerts its influence. There are the usual potential problems of simultaneity and unobserved variable bias. To put these in stark form, suppose that differences in life expectancy across countries were simply determined by differences in (quantity and quality of) education. Suppose also that life expectancy is much better measured than education. Then when it is introduced it will rob standard schooling measures of significance and likely bias the coefficient on schooling downwards. More research seems to be required.

IV. Static Market Externalities: Micro Evidence

Neighbourhood Effects on Schooling

Wolfe and Haveman (2001) catalogue a large number of studies that examine the impact of parents' (and sometimes grandparents') education on offspring's success in school, and a smaller but still sizeable number of studies that examine neighbourhood effects. Since schooling has a well-established strong effect on earnings, I include these studies here under market externalities. (Similar studies of e.g. teen pregnancy, crime and health are discussed in the next section, which is on non-market externalities.) Most of these studies have used U.S. panel data from the Panel Study of Income Dynamics (PSID) or (less frequently) the National Longitudinal Surveys (NLS).

It is well-established that parental education (and family background more generally) has an important effect on children's schooling and earnings. However, in my

view this is largely irrelevant in a discussion of human capital externalities since I believe that families internalize most of these benefits. That is, one of the benefits people expect from accumulating human capital is that they will be able to do more for their own children in a variety of ways. Rational people should take this into account when deciding how much schooling and training to obtain.

Neighbourhood effects, on the other hand, may reflect genuine externalities. Wolfe and Haveman list eight studies that examined the impact of a variety of neighbourhood characteristics reflecting human or social capital on various measures of success in schooling. (Five of the studies use the PSID, one the NLS, and two use Census data.) Six of the studies, whose dependent variable was years of schooling (2 studies) or whether the individual graduated from high school (4 studies), found mainly significant neighbourhood effects. Variables that were significant in these studies include:

Average family income
Percent in managerial/professional jobs (2 studies)
Percent of families with income > $30,000
Percent of young adults who dropped out of high school
Percent of households in poverty

Insignificant effects were found for a number of neighbourhood variables by Lillard (1993), who studied determinants of years of college planned and attended for NLS males graduating in 1972, and by Plotnick and Hoffman (1999) who did a logistic regression to explain whether PSID women who graduated between 1976 and 1987 obtained any post-secondary schooling. Significant variables in these two studies were:

Occupation-specific difference between mean neighbourhood and national earnings for professionals/managers (Lillard)
Percent college-bound in high school (Lillard)
Number of library hours in high school (Lillard)
Percent of families with income > $30,000 (Plotnick and Hoffman)

Insignificant variables were:

Household earnings in school district (Lillard)
Occupation-specific difference between mean neighbourhood and national earnings for occupations other than professionals/managers (Lillard)
Percent professionals/managers in zipcode (Lillard)
Percent craftsmen in zipcode (Lillard)
Variance in education in zipcode (Lillard)
Percent of female-headed families with kids (Plotnick and Hoffman)
Percent of families with income < $10,000 (Plotnick and Hoffman)
Neighbourhood non-elderly poverty rate (Plotnick and Hoffman)
Percent of families receiving welfare (Plotnick and Hoffman)

A possible interpretation of these results is that neighbourhood human and social capital is important in determining whether people graduate from high school, but that, *conditional on high school completion*, neighbourhood effects are less important. In other words, accessibility to post-secondary education in the U.S. may be less of a problem than unequal opportunity at the secondary level. It may be that low quality schools in poor neighbourhoods are a trap that saps human capital accumulation in the U.S., but high school graduation frees individuals from this trap and allows them access to more equal opportunity. Whether such conclusions could carry over to Canada, to any degree, is an interesting question. I am not aware of any evidence on this.

Neighbourhood Effects on Earnings

Another important strand in the micro study of human capital externalities includes contributions that look at neighbourhood effects on earnings. Controlling for own education and experience, Rauch (1993) found that individuals' earnings rose by 3.1% in response to an additional year of average education in an SMSA (Standard Metropolitan Statistical Area). Similar effects were found by Moretti (1999). However, Rudd (1996) finds that Rauch's results become insignificant when he constructs a 14 year panel of March CPS data and introduces state fixed effects. Heckman, Layne-Ferrar and Todd (1996), also using Census region data, fail to find any systematic evidence of human capital spillovers.

Acemoglu and Angrist (2000) have recently examined human capital earnings externalities in the U.S. using an interesting new approach. First they reproduce the apparent evidence in favour of externalities by estimating a Mincer equation for individual earnings with average schooling in the individual's state, s^*, included as follows:

(4) $\log E = b + cs + c^*s^* + d(x) + u$

where u is an error term. When a simple OLS regression of this form is run both c and c^* are approximately equal to 0.07. If this result could be trusted it would say that the internal and external benefits of human capital are equally significant.

Estimating (4) by OLS may not be safe because of the strong possibility of correlation between u and s^*. States' unobserved attributes may well affect earnings and average education in the same direction. It therefore becomes advisable to apply instrumental variable (IV) methods.

In recent years economists have taken advantage of a simple natural experiment to attempt to get better estimates of c in (3). Standard practice in North America is to enroll in Grade 1 each September all children who will turn 6 years old by the end of the year. This means that students born later in the year must spend a longer timespan in school before they reach minimum school-leaving age (MSLA). Census data in the U.S. for some years record individuals' quarters of birth, *QOB*. Since the MSLA is binding for some students, *QOB* is correlated with s. However, it is unlikely to be correlated with u since earnings shocks for adults should not be correlated with their season of birth. Thus *QOB* should make a good instrument for s.

Acemoglu and Angrist apply a conceptually similar technique to obtain instruments for s^* in (4). U.S. states differ in their minimum school leaving ages ("compulsory attendance" - - *CA*) and also in their minimum working ages ("child labor" - - *CL*). For each individual in their sample of U.S. males aged 40 –49 Acemoglu and

Angrist form variables *CA* and *CL* based on the legislation in force in the state of the individual's birth, when that inidividual was aged 14.[16] *CA* and *CL* are correlated with s^*, but are arguably independent of earnings shocks u in (3) since they relate to legislation in force about 30 years before the observation of earnings. They thus should make good instruments for s^*.

With their IV approach, Acemoglu and Angrist obtain estimates of c^* approximately equal to, and insignificantly different from, zero. Thus, their point estimates suggest human capital externalities in the U.S., at least for middle-aged males are approximately zero. They issue several caveats, however, and others have also pointed out the following:

1. The estimates of c^* are not very precise. The 95% confidence interval includes a 6% return to externalities. (On the other hand, the results are robust to a range of alternative specifications in the estimation.)

2. While externalities may not be important for middle-aged males they might be important for other groups, for example minority youth, on whom a lot of policy attention focuses.

3. Externalities may not be very strong at the state level, but they could be stronger e g. at the city level.

V. Non-market Externalities

It is important to recognize the distinction between non-market *effects*, and non-market externalities of human capital. It is well-established, for example, that greater schooling is associated with better health, greater longevity, and reduced probability of teenage pregnancy both in microdata and in cross-country comparisons. But such non-market effects could, conceivably, be mostly internalized. This may be particularly true in advanced countries like Canada where there is a high standard of public health, a

[16] Males are used because females differ much more in years of labor force experience, and the latter are unobserved in the data. The age group 40-49 is chosen because workers in this group are on the flattest portion of the age-earnings profile.

relatively clean environment, generally safe handling & packaging of food, near-universal access to refrigeration and so on. Individual knowledge of hygiene, safe food-handling etc. may be less crucial than at an earlier stage of development.

There have been a large number of studies on the non-market effects of education. (See e.g. Behrman and Stacey, 1997; McMahon, 1999; and the Wolfe and Haveman, 2001 survey.) While these studies may be subject to omitted variable and simultaneity biases, and experience the typical difficulties in finding adequate instruments, many believe they provide evidence of strong effects. Wolfe and Haveman conclude that the non-market benefits of education are likely similar quantitatively to the market benefits. This has two possible alternative implications:

1. *Non-market effects are mostly internal*: If non-market effects are mostly internal we face a puzzle. Suppose the private rate of return to schooling averages 10%, as suggested e.g. by the international evidence reviewed by Psacharopoulos (1994). Then if non-market returns are of a similar magnitude, and are internalized by individuals, private returns would be about 20%. This presents a puzzle. We are used to believing that average returns on human capital may exceed average private returns on other assets, due either to the riskiness of human capital investment or borrowing constraints. However, in countries with advanced financial systems, relatively generous student loans, and high rates of participation in post-secondary education, it seems hard to believe that private returns to education could so greatly exceed the returns on other forms of investment. But, if this were the right interpretation, there would be reason to review and perhaps enhance our student loan plans.

2. *Non-market effects are mostly external*: If this is the case, then there is a good case for high rates of subsidy. Education is, of course, already highly subsidized, so that it is not clear there is a case for *increased* subsidies. However, if non-market effects are as sizeable as suggested by Wolfe and Haveman then it seems quite possible that a case for increased subsidies could be constructed.

So, either way, sizeable non-market effects of education can provide a rationale for strong public intervention - - although in different forms depending on whether non-market effects are mostly internalized.

Health and Longevity

Here are some representative results on the impact of education on health and longevity:

1. Feldman et al. (1989) studied the relative risk of death from heart disease in the U.S. for those with only 8 – 11 years of schooling vs. those with 12 or more years. He found that the risk was 85% greater for males aged 45-64, 25% greater for males aged 65-74, and 37% greater for females aged 65-74.

2. In a widely-respected study for the U.S. Kenkel (1991) found that an additional year of schooling led to an average of 1.6 fewer cigarettes smoked per day for men and 1.1 fewer for women in 1985. On average, an additional year of schooling led to 17 minutes more exercise per week.

3. There is "substantial evidence that child health is positively related to parents' education". (Wolfe and Haveman, 2001, Table 2, citing e.g. King and Hill, 1993; Glewwe, 1999; and Lam and Duryea, 1999.)

4. There is "considerable evidence that own schooling positively affects one's health status". (Wolfe and Haveman, 2001, Table 2 citing e.g. Grossman and Joyce, 1989; Kenkel, 1991; and Strauss et al. 1993.) It also increases life expectancy (Feldman et al., 1989; King and Hill, 1993) and lowers prevalence of severe mental illness (Robins et al., 1984).

5. McMahon (1999) estimates the determinants of a number of non-market variables for a large cross-section of countries. He then simulates alternatively the effects of a 2

percentage-point increase in the fraction of GNP spent on education and a 20 percentage-point increase in secondary enrolment over a 40 year period beginning in 1995. He compares simulated results of these policy changes in 2035 with those of a simulation that continues current policies. The increased expenditure simulation leads in the U.S. to a drop in infant mortality of about 0.3% (from 10.99 to 10.96 deaths per 1,000 births) and an increase in life expectancy from about 76 to 77 years (McMahon, 1999, Figure 12.13). Corresponding effects in the U.K. are a 5% drop in infant mortality (from 8.90 to 8.84 per 1,000) and a rise in life expectancy from about 76 to 77.5 years. Impacts of the simulated enrolment increase in the two countries are about two thirds as large as those of the spending increase.

6. From a public finance perspective, it is useful to distinguish between the impacts of education on morbidity and mortality. Reductions in morbidity likely in general lead to reduced public health care expenses - - an external benefit. On the other hand, increased longevity leads to higher public pension payments and perhaps also increased health spending. In recent years there has been a substantial decline in adult smoking. In attempting to assess the implications, Shoven et al. (1987) estimated that if no one born in 1920 in the U.S. had smoked, the annual cost of current social security benefit payouts would have been $14.5 billion higher due to increased longevity. In contrast, the reduced morbidity due to decreased smoking has been estimated to have relatively small effects on health spending (compared e.g. to tobacco taxes) since, regrettably, smoking related deaths on average come comparatively quickly after the onset of illness.

It is useful to look at one of the most widely cited papers in the education and health literature more closely. Kenkel (1991) used a 1985 U.S. dataset that included variables on both health behaviour - - smoking, drinking, and exercise - - and knowledge of the effects of those forms of behaviour. By 1991 it was clear that there was a strong empirical relationship between education and health. Kenkel wanted to find out more about how precisely the two were linked. He therefore turned the focus from explaining health outcomes to studying the determinants of health *behaviour*. One benefit is that

some unobserved or unobservable individual differences that affect both schooling and health directly - - such as chronic health conditions that interfere with schooling attainment as well as later health - - should have less effect on the observed relationship between schooling and health behaviour.

It turns out that education is not only associated with greater health, it is also associated with better health behaviour.[17] Kenkel points out there are at least four reasons for the latter association: (i) education may improve health knowledge resulting in improved health behaviour (greater allocative efficiency in choice of health inputs), (ii) unobservable differences between individuals that affect both schooling and behaviour (e.g. time preference rates), (iii) omitted variable bias, (iv) higher schooling may lead to greater efficiency in health production, for given health inputs. He also mentions, in passing, that greater education could change preferences (e.g. by reducing time preference rates), leading to altered health behaviour.

Kenkel finds that controlling for health knowledge only reduces the coefficient on schooling in his estimated tobit equations by 5 – 20%. Thus, the influence of schooling does not appear to operate mainly through its impact on health knowledge. He attempts to control the most important sources of omitted variable bias, for example by including a family income variable. But it is impossible to control for unobserved variables, or to identify impacts on preferences or efficiency in health production. Thus, Kenkel concludes that exactly why schooling is so strongly associated with health behaviour is unclear. It is hard to escape the feeling that it will remain so.

Kenkel's lack of conclusion regarding the link between education and health behaviour is instructive, since it seems likely that unobservable individual differences, omitted variables and so on may also account for part of the observed relations between education and fertility, longevity, crime, civic participation and so on. The belief that

[17] Interestingly, Kenkel found that, controlling for health knowledge and family income, higher schooling led to more total consumption of alcoholic drinks per week. On the other hand, it also was associated with a lower incidence of heavy drinking, which is the prime health risk from alcohol.

interventions to raise schooling will have major beneficial social impacts may ultimately find its firmest basis in theory and judgement, rather than in empirical evidence.

Two other points that arise in connection with Kenkel's work are worth emphasizing:

1. Kenkel found that for cigarettes there was an important interaction between health knowledge and schooling. Those with higher schooling reduced their smoking more for a given increase in health knowledge. (Parallel results were *not* found for drinking and exercise.) He also points out that earlier studies found that, prior to the Surgeon General's report in the early 1960's (which had a strong impact on knowledge of the health effects of smoking), higher schooling was not related to lower smoking. Thus, at least for smoking, it appears that schooling and health knowledge have reinforcing effects.

2. Two of the three behaviours Kenkel studies are especially interesting since *the behaviours themselves*, rather than own health outcomes, may cause externalities. There has been much recent emphasis on the dangers of second-hand smoke. And the dangers of drinking heavily and driving have been obvious for a long time. Kenkel refers to earlier studies that found that smoking externalities were fully, or more than fully, internalized by smokers in the U.S. as a result of tobacco taxes (Keeler et al., 1989; and Manning et al., 1989). However, Kenkel also mentions that the evidence as of 1991 for the U.S. was that taxes on alcohol were not sufficient to internalize externalities from drinking.

Fertility

Many studies in developed countries indicate that high school completion and increased years of schooling reduce the probability that teenaged females will give birth. More generally, Wheeler (1984), McMahon (1999) and others find that there is a strong negative effect of education on fertility in cross-national data. McMahon estimates, for example, that when strong family planning programs are in place an increase in the total female enrolment rate (primary plus secondary) from 50% to 100% reduces the fertility rate on average by 1.3 children per woman. When average family planning is in place the reduction is by 0.4 children.

In his 40 year simulations of the effects of raising education expenditures by 2 percentage-points as a fraction of GNP or raising secondary enrolment by 20 percentage-points, McMahon (1999) finds that the increased expenditures would reduce fertility by about 10% in 2035 in the U.S. In the U.K. the effect is about 15%. The impact of the enrolment policy is about half as great as that of the expenditure policy in the U.K., and about two thirds as great in the U.S.

The negative impact of education on fertility raises interesting issues. In an LDC with high population density and a high growth rate of population it is possible that reduced fertility would be seen as having positive external effects. On the other hand in advanced countries where the birth rate is already significantly below the replacement level, as in Canada, society may be seen as being a net gainer from additional births. Intergenerational accounting exercises in Canada, the U.S. and other countries, for example, indicate that the expected contribution of the average young person to the public purse over their lifetime is substantially positive. Also, if one believes that human capital in general has positive externalities, additional children will confer substantial externalities on society over and above their net contribution to the public purse. This suggests that the fertility-reducing impact of schooling should likely be regarded as an external cost, rather than an external benefit.

Crime

Witte (1997) and McMahon (1999) review the literature on the relationship between education and crime. Briefly, it is found that the impact of education, holding other factors constant, on the propensity of those who have completed schooling to commit crime is weak. However, whether young men are productively occupied - - i.e. enrolled in school or employed - - has a strong impact on their likelihood of commiting an offence. In cross-national data McMahon finds that both enrolment rates and unemployment rates have strong and significant effects (of opposite signs). In his simulations, a 20 percentage-point enrolment increase would reduce the homicide rate in

the U.S. by about 15%. The same policy in the U.K. would reduce property crime by a small amount (less than 1%).

The benefit of keeping teenage males occupied and under supervision has recently been highlighted by the wave of arson in Australia over the Christmas (i.e. summer) holidays. Other striking illustrations of the principle can be seen if we look back in history. The high crime rates of the early Victorian period in the U.K., for example, may have had much to do with the broad base of the population pyramid and lack of public schooling. Conversely, the large increase in crime (particularly property crime) in the U.K. since the 1970's may be associated with the increase in youth unemployment rates since that time. (Note that youth unemployment rates may be less sensitive to employment declines in Canada due to our high enrollment rates in post-secondary education.)

Finally, a recent influential study has been done for the U.S. by Lochner (1999). Lochner estimates the social benefits of high school graduation through reductions in crime, taking into account the costs of incarceration and the costs to victims as reported by survey respondents. The extra social benefits amount to almost 20% of the private return. He even considers this to be a conservative estimate, since a number of crimes are not included. Also omitted are the effects on crime beyond the age of 22, reductions in the number of crimes by those still committing crimes, criminal justice and law enforcement costs, and finally, the overall benefits from feeling safe.

Civic Participation and Political Effects

The role of education in preparing individuals for productive participation in civic life, especially in a democracy, has often been advertised as one of the most important potential externalities of schooling. Recently there have been many attempts to measure the impact of schooling on civic and community participation and the quality of political institutions, using both individual and cross-country data.

There is some evidence that individuals with greater education are more likely, e.g., to vote in elections, although there is some dispute over whether the determining factor is the absolute or relative level of education. (Wolfe and Haveman, 2001, reference Gintis, 1971, and Campbell et al., 1976.) Higher schooling is also associated with greater charitable giving and more volunteerism (Dye, 1980; Hodgkinson and Weitzman, 1988; Freeman, 1997).

In international data it is found that higher education has a positive effect on democratization and political stability. McMahon (1999, 2001) finds significant effects of secondary education rates on indexes of democratization, human rights, and political stability. (See also Barro, 1999, for similar results.) These effects are found after controlling for both per capita income, and military expenditures as a fraction of public spending. Strongest effects are found for secondary enrolment rates lagged from 15 to 20 years. McMahon also estimates the impacts of democratization, human rights and political stability on growth, so he is able to estimate the feedback effects of education on growth via these avenues. He finds a strong effect.

While the civic and political impact of education may often be positive, we are all also familiar with possible negative effects. The schools can obviously be used for undesirable forms of indoctrination - - as seen in most extreme form in Nazi Germany, Mao's China or the former Soviet Union. And the effects of many young men having received heavy indoctrination in extremist schools in Afghanistan and Pakistan in recent years hardly seems to have been beneficial. Closer to home, fears of the socially fragmenting effects of rising enrolments at private religious-based schools have recently been expressed in Canada.

Some comfort can perhaps be taken from the fact that it is "a little education" that is a dangerous thing. It may be that primary schools are the best places to teach unthinking allegiance to dogma, and that secondary and postseconday education leads to more critical thinking. If so, increased schooling in Canada at this time may be more likely to produce positive than negative social and political effects.

Tax and Transfer Effects

Several studies find that the more educated are less likely to rely on public transfers, even when eligible for benefits. (Wolfe and Haveman, 2001, cite Kiefer, 1985; Antel, 1988; and An et al. 1993.) This is no doubt an important effect. But probably more important, quantitatively, is the impact on tax receipts. In Canada today the modal marginal tax rate for university graduates is well in excess of 50% - - taking into account sales and excise taxes as well as income tax. This means that every additional $1,000 in earnings generated by university education leads to more than an additional $500 in taxes.

Recently, Collins and Davies (2001) have estimated the wedge between before and after-tax rates of return to first-degree university education in Canada and the U.S. The 1998 SCF was used for Canada, and the 1998 CPS was used for the U.S. The median reduction in the rate of return in Canada due to taxes, averaging across the sexes, was 1.9 percentage points. In the U.S. the corresponding reduction was 1.1 percentage points. At higher incomes the effects were larger - - 2.8 percentage points for 90th percentile Canadian males, for example, and 1.9 percentage points for corresponding U.S. males. (For comparison, median pre-tax returns averaged across the sexes were 12.5% in Canada and 13.0% in the U.S.)

Environment

There is some evidence that greater education leads to beneficial environmental effects. MacMahon (1999) finds, e.g., in his cross-country study that rates of deforestation are lower in countries with higher schooling. (The effects of higher income are controlled for.) Smith (1997) finds that more educated people in the U.S. are both better informed about environmental hazards, and more likely to take effective action to avoid or reduce such hazards.

An important trend in education in Canada and other advanced nations for at least the last two decades has been instruction in environmental awareness. It would in fact be a disappointing comment on the effectiveness of education in modifying behaviour if we found that schooling did not make people more environmentally responsible. There is room for research, for example on whether more educated households emit less greenhouse gases, holding income and other characteristics constant. One could investigate, e.g., whether, income constant, people with more education drive fewer miles, are less likely to own SUV's etc.

Consideration of environmental externalities of education raises an interesting point about the role of education that is emphasized by Arrow (1997). Historically, *indoctrination*, that is the formation or modification of preferences and behaviour, was seen as a legitimate and important goal of education. Today, our more liberal society shuns explicit recognition of this goal, but in fact expects its schools to devote a significant effort to training students to adopt "appropriate behaviour". Thus there is emphasis in our schools on anti-racism, anti-sexism, and respect for diversity as well as environmental awareness. It may be that it is in these areas that the public expects to get some of the largest externalities from primary and secondary schooling.

Inequality

Discussions of the social or indirect effects of education often touch on the impact of education on inequality. Indirect effects of education on incomes do generally represent externalities. But is the impact of education on income *inequality* an externality? The short answer is that it can be considered an externality if people care about inequality in the sense that they would be willing to bear some cost to reduce it. This parallels the sense in which some environmental effects represent externalities.

Results on the impact of education on inequality are mixed. McMahon (1999) finds that the level of primary schooling in a country has an insignificant effect on income inequality. On the other hand, higher secondary enrolment rates reduce

inequality. These results are for a broad cross-section of countries at different stages of development. Recent studies of OECD countries, and especially the U.S., indicate that increases in schooling that have taken the form of higher post-secondary graduation may have been one of the forces that helped to increase wage and income inequality in recent decades. (See e.g. Acemoglu, 1998, and the discussion in OECD, 2001.)

A full theoretical discussion of the impact of education on inequality would take a whole volume. However, some interesting insights can be pointed out quickly. A good starting point is the Mincerian model embodied in (3), which summarizes the equilibrium wage differentials that would hold for different levels of schooling in a society with a perfect capital market (and therefore a constant rate of return to investments in education). The Mincer equation indicates that, in long-run equilibrium, the proportional wage differentials for different schooling levels are constant. Income inequality is therefore only affected by changes in the *number* of workers at different levels of schooling, s.

The Mincer equation indicates that for workers of the same level of experience the variance of log earnings, $V(\log E)$ should be a weighted sum of the variances of schooling, $V(s)$, and the error term. If all workers gain a year of schooling, neither $V(s)$ nor $V(\log E)$ will change. Since $V(\log E)$ is a good measure of inequality in earnings, this means that inequality is unaffected.[18] On the other hand, it is easy to see that if those with higher s got a larger increase in schooling, inequality would rise. And, inequality would fall if the lower educated got a bigger increase in s. The latter point has some significance in North America, in view of the fact that there are concentrations of illiterate and very low skilled workers in both Canada and the U.S., despite the overall high level of schooling. (See e.g. OECD, 2001, p. 26, and Crompton, 1996.) Working to reduce the size of these poorly educated groups seems very likely to pay off in reduced inequality.

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[18] The variance of logatithms is often used in studies of wage inequality for reasons of analytical and computational convenience. However, its use also makes theoretical sense since the distribution of labor earnings is approximately lognormal. In the lognormal case, $V(\log E)$ describes the level of inequality unambiguously.

Moving beyond the Mincer model, one must recognize that changes in the relative supply of workers with different levels of *s* will affect earnings differentials in the short-run and in the long-run as well if we do not have perfect capital markets. Consider the following simple model set out in Davies and Wooton (1992). Assume a small open economy (i.e. a country that is a price taker for tradable goods) that produces two tradable goods, and suppose that there are three factors of production: physical capital, skilled labor, and unskilled labor, *K*, *S*, and *U* respectively. Depending on technology and factor endowments any pair of these factors may be "friends" or "enemies". If *K* and *S*, for example, are friends a rise in the number of *S* workers will increase the rental rate for *K* (and reduce wages of *S* of course). If *K* and *S* are enemies, then an increase in *S* numbers will reduce returns for both *S* and *K*. In the model described, each factor must have at least one friend, and friendship or enmity are mutual.

As discussed in Davies and Wooton (1992), in the model described there are two "extreme" factors and one "middle" factor, where an extreme factor is one used most intensively in either the import-competing or export industry. The extreme factors are mutual enemies, while both are friends of the middle factor. Davies and Wooton report that U.S. data indicate exports and imports are intensive in *S* and *U* respectively. This would suggest that in the U.S. case an increase in the number of skilled workers should reduce the wages of the unskilled and increase returns to capital. These indirect effects would tend to raise income inequality, which may perhaps help to explain the rising trend of inequality in the U.S. in recent years. Davies and Wooton suggest that, unlike the U.S., Canada's exports (which are relatively heavy in commodities) may be *K* intensive and its imports (skewed towards manufactured goods) *S* intensive. This would make *S* a friend of *U* and an enemy of *K*. The result is that the indirect effects of a rise in the number of skilled workers should tend to reduce inequality, by raising the wages of unskilled workers and reducing returns to capital. This could perhaps help to explain why the large increase in the relative number of university graduates in Canada has produced a much smaller increase in wage and income inequality than in the U.S.

Now, let us consider dynamic effects, that is the impact of changes in investment and resulting capital stocks induced by an increasing relative supply of skilled workers. According to Davies and Wooton, a rise in *S* numbers in the U.S. should induce an increase in the *K* stock (since *K* returns go up). The increase in the *K* stock will tend to raise *S* wages, offsetting to some extent their initial fall due to the expansion of *S* numbers. Effects on inequality from this feedback are uncertain, however, since *U* wages will also be bid up. In the Canadian case, with *S* and *K* being enemies, the induced increase in the *K* stock will not occur, and so dynamic effects should perhaps be less important.[19]

Acemoglu (1998) has pointed out that an increase in the number of highly educated workers may affect not only the growth of other factors of production over time, but the direction of technological change. A rise in the number of college educated workers will, in the short-run, bid down their relative wages. This will give innovators an incentive to develop technologies that make greater use of more highly skilled workers. This will increase the relative demand for the college educated, causing a rebound in their relative earnings that may take the college wage premium to a higher level than it enjoyed in the very beginning. Hence inequality may initially decline in response to a rise in postsecondary participation, but then increase in the long-run.

Acemoglu's story seems to fit the U.S., the U.K. and to an extent other countries like Canada, in recent decades. There was indeed a large increase in the number of college educated workers in the U.S. in the 1960' and 70's. And college wage premia did in fact decline - - to the extent that there was concern about the "overeducated American". But then there was a revolution in information technology that led to the rise of the new economy, and at the same time a rebound in the college wage premium. It is thus plausible that the rising access to postsecondary education in the U.S. in the

[19] The predicted lower rate of investment in Canada than the U.S. is strikingly consistent with the observed lower rate of business investment in Canada over the 1990's. While this is certainly a plus for the Davies and Wooton analysis, it must be kept in mind that their model is highly stylized and may have nothing to do with the observed trends at all. Nevertheless, we have some interesting hypotheses here which ought to be tested in more formal work.

postwar period ultimately caused increasing inequality - - not only in the U.S. but elsewhere as the skill-biased technical change spread around the globe.[20]

While effects of education on inequality may be interesting, it must be concluded that their direction is ambiguous. This is perhaps fortunate for the analyst of externalities, since the task of putting a *value* on the inequality effects of education would be formidable.

Size of Effects

Haveman and Wolfe (1984) tackled the problem of estimating the size of non-market effects in dollar terms. They pointed out that if different inputs are being used, say, to increase health, the inputs ought to be used up to the point where the ratio of their marginal products equalled that of their prices. Suppose the both schooling, s, and some other input, x, (e.g. personal health expenditures) have marginal products, MP_s and MP_x in the production of health. The price of x, p_x, is observed, but not that of schooling. Note that the unobserved "price of schooling", p_s, is a shadow price. It should correspond with marginal willingness to pay for schooling, which by this reasoning can be found from:

(5) $\quad p_s = (MP_s/MP_x)p_x$

Wolfe and Haveman (2001) provide a table with a few such estimated shadow prices. They calculate that the non-market value of an extra year of school includes:

- increased consumption efficiency worth $290,
- better health worth $8,950 in asset value,
- a $170 per annum reduction in policing activity, and
- from $30 - $50 in increased volunteering.

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[20] Acemoglu (1999) points out some of the effects for LDC's that import the new technology but use less skilled workers in conjunction with it than do the advanced countries. The result is to exaggerate the TFP gap between rich and poor countries. In the Canadian case, we have observed a less rapid increase in

Using a 10% real rate of return for all assets and human capital, in a community where mean family income was about $40,000 per year (approximately correct for the U.S. at the time when the various studies used were performed), an additional year of schooling for all earners in a family would raise private income by about $4,000. The four non-market effects calculated by Wolfe and Haveman add up to about $1,400. Lochner's crime effect would be worth a further $800. Impacts on fertility, civic participation, and other factors like improved efficiency in labor market search have not been included. Thus, it is not hard to see how Wolfe and Haveman reached their conclusion that the value of non-market effects was of about the same size as that of market effects.

It is important, of course, to take account of the fact that not all of the non-market effects included by Wolfe and Haveman are externalities. Reductions in crime and increased volunteering certainly fall in this category, but probably the bulk of health benefits accrue to the individual. McMahon (1999) argues that about three quarters of the static non-market effects of schooling represent externalities. If one allowed for say half of those measured effects being due to unobserved or unobservable variables, static non-market externalities would be three eighths of the private rate of return to schooling. These externalities would thus add about 3 - 4 percentage points to the social rate of return to education.

VI. Conclusion

What does this survey tell us about human capital externalities? First, and perhaps most importantly, it emphasizes that our knowledge of these externalities is imperfect, and estimates of their size have large error bounds. But second, it is possible to make some point estimates of the magnitude of the component externalities. A convenient way to summarize these is in terms of how many % points these externalities

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inequality since the 1970's than in the U.S., which might be explained by our greater relative increase in the supply of college graduates and some lag in adopting the technical changes emanating from the U.S.

may raise the social rate of return to education above the private after-tax rate of return. Here is a summary:

1. Dynamic externalities of education: **1 - 2 % points**. The conclusion in section II was that the dynamic effects of education appear to operate mostly via TFP growth. It is difficult to know what fraction of this effect represents externalities, but McMahon (1999) does provide explicit estimates (which give the range indicated here) and they are not inconsistent with other evidence from the literature.
2. Static market externalities: **0 % points.** A growing number of recent studies, in both the macro and micro approaches, find no evidence of static earnings externalities.
3. Static non-market externalities: **3 - 4 % points.** This conclusion rests on the Wolfe and Haveman assessment, with deductions for non-market effects that are not externalities and for bias due to unobserved or unobservable variables, as discussed in the preceding section.
4. Tax effects: **2 % points.** Based on Collins and Davies.

Adding up these "guesstimates", it appears that education externalities could add something like 6 - 8% points to the after-tax private rate of return to education. Interestingly, this wedge is of similar size to the gap between private after-tax rates of return (17 and 20% for bachelors' degrees for men and women respectively)[21] and total rates of return (10% for both genders)[22] found for Canada in 1995 by Vaillancourt and Bourdeau-Primeau (2002). This suggests that subsidies to education that are already in place, at least at the postsecondary level, may be of about the right size to raise private after-tax rates of return to the level of the social rate of return. Much further research would of course be required to establish this as a firm result.

[21] As noted earlier, this is based on the private costs of obtaining a degree.
[22] Again, as noted earlier, this takes account of the total cost, private and public, of obtaining a degree

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